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HYDROGEOLOGICAL ASSESSMENT OF DELHI PARK WASTE DISPOSAL SITE, PICTON

AUGUST 1989

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Environment
Ontario

Jim Bradley
Minister

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HYDROGEOLOGICAL ASSESSMENT OF DELHI PARK
WASTE DISPOSAL SITE, PICTON

Report prepared for:
Waste Site Evaluation Unit
Waste Management Branch

Report prepared by:
Water and Earth Science Associates Limited

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1.0 INTRODUCTION

The Province of Ontario currently generates an estimated 1.5 million tonnes of solid domestic and industrial waste per year. Due to the long list of health and environmental problems associated with waste disposal sites, the Ministry of the Environment (MOE) has made a concerted effort over the last decade to upgrade waste disposal facilities into viable sanitary landfill sites. Sanitary landfills are now the most common disposal method being utilized in Ontario.

Many landfills in Ontario have been closed within the last 10 to 15 years. Information on waste disposal practices, the type of waste that was disposed of and the closure procedures utilized at these landfills is sparse. The MOE is presently implementing a program to investigate all closed and active waste disposal sites in the Province. The aim of this program is to ensure that all relevant information regarding the sites' existing or potential impact on either humans or the environment is available. Once this information is provided, remedial options can be investigated and implemented where necessary.

Phase III of the MOE's program of waste disposal facility evaluation involves the investigation and monitoring of hydrogeology as well as surface and groundwater contamination potential at selected sites. The present investigation is concerned with the closed Delhi Park Landfill site in the Town of Picton. The objectives of the monitoring program are summarized as follows:

- 1) to determine the leachate characteristics with attention to the possibility that an unidentified industrial liquid waste may have been disposed of at the site
- 2) to define any existing or potential impacts on surface water including the Picton Bay
- 3) to define the extent of a landfill gas hazard
- 4) to define the site's present physical condition, and
- 5) to develop recommendations that will lead to site improvements with respect to site monitoring and remedial action.

2.0 BACKGROUND

The Town of Picton Landfill site is now closed and the land is being used as parkland. The site is located south of Mary and William Streets (Figure 1). It shares an entrance road with a sewage treatment plant, which is located east of the site. A cemetery borders the site to the south and southeast.

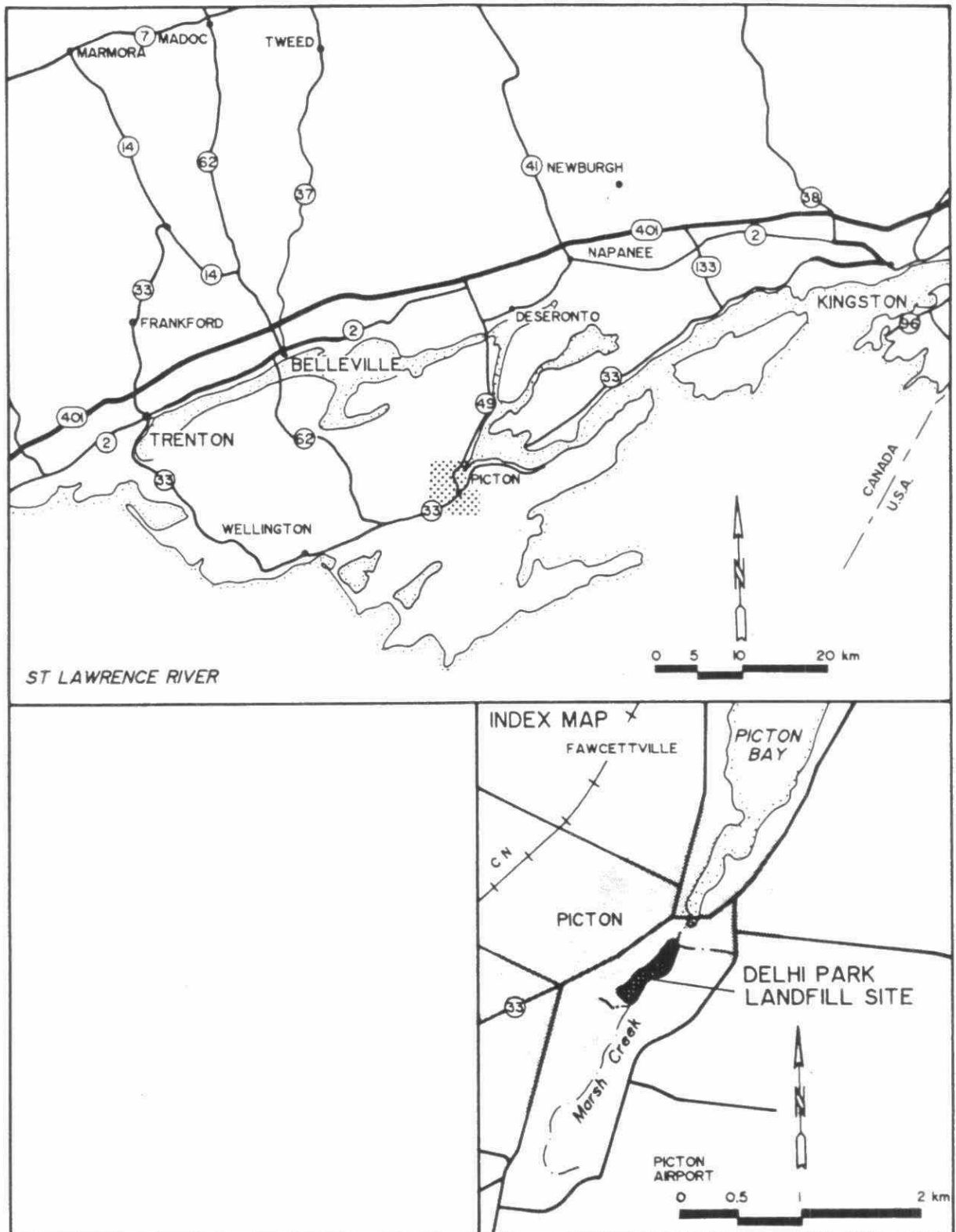
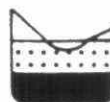


FIGURE 1

LOCATION MAP

DELHI PARK LANDFILL SITE
PICTON, ONTARIO



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Residential property is located to the east and the west while commercial and industrial property borders to the north and northwest. Prior to landfilling practices, the natural vegetation consisted of marshlands. Marsh Creek flows from the south, through the centre of the site, and into Picton Bay to the north. Picton Bay serves as the municipal water supply for the Town of Picton. Significant seasonal variation in discharge was observed in Marsh Creek. During periods of low flow an oily film and areas of scum were observed along the banks of the creek.

The site was operated and is still presently owned by the Town of Picton. The exact date that landfill operations began is not known, but it is believed that farm machinery and canning industries began landfilling their used equipment and waste in the north-western corner of the site in the early 1900's. Domestic waste was landfilled on the eastern quarter of the site beginning in the 1940's. In the 1950's, landfilling of domestic waste continued on the west side of the site and proceeded in a counter clockwise direction around the remainder of the site (Figure 2). In some areas the waste was landfilled in two lifts. Construction debris from the reconstruction of Main Street in the 1970's was filled in two topographically high areas on the eastern third of the site. No official records of waste types or volumes exist. Open burning was not regularly practiced at the site. An inventory of industrial plants that may have landfilled at the site has been compiled (Appendix A).

The landfill was closed in late 1979 when its capacity was exhausted. A 0.6 m (2 ft) thick clean fill cap was placed over the site and the area was designated as parkland. From 1983 to 1984 the Public Works Department carried out an extensive landscaping and park construction program. Present land uses at the park include a playground for young children, a baseball diamond, jogging and walking paths and a 'Participation' exercise course.

The Town of Picton Sewage Treatment Plant is located immediately east of Delhi Park. The outfall from the plant is discharged into Marsh Creek.

During the late 1960's, the MOE recommended that the landfill operation should not occur closer than 30 m (100 ft) to Marsh Creek. However, operations did proceed at certain times up to the creek bank. These practices, along with the fact that the creek bed had been tiled in, prompted the MOE to conduct a geochemical sampling survey in 1971 and 1977 (the results are included in Appendix B). In the 1971 sampling, the landfill was found to be impacting on Marsh Creek, as indicated by elevated TDS, nitrogen, phosphorous, BOD and coliform bacteria concentrations. These concentrations were above the present day drinking water objectives and allowable groundwater quality degradation limits. The water chemistry in Picton Bay was not

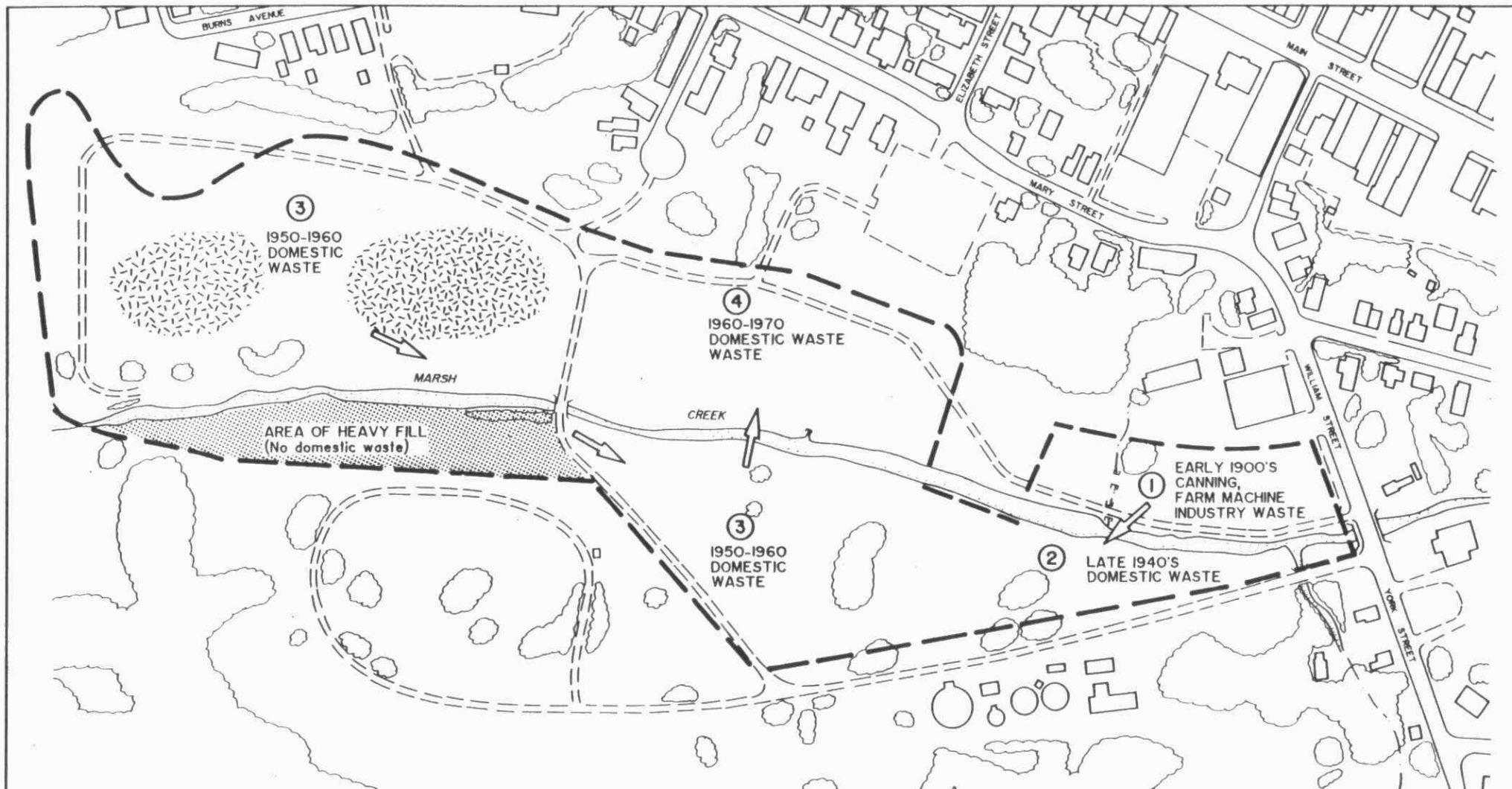


FIGURE 2

LANDFILL DEVELOPMENT AND OPERATIONS

DELHI PARK LANDFILL SITE,
PICTON, ONTARIO.



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measured at this time. The survey in 1977 revealed that the landfill was continuing to affect Marsh Creek. Some of the 1977 test parameters showed increases in concentration since 1971 while others decreased.

The structural geology in the vicinity of the Delhi Park Landfill is very complex and may have a bearing on the site hydrogeology and hydrochemistry. The Picton fault zone, which runs directly through Delhi Park, consists of two or three north-northeast striking faults with the down thrust blocks on the west side.

Bedrock in the area consists of Middle Ordovician limestone (grey, fine-medium grained, crystalline). Surficial materials consist of fine to medium grained, massive to bedded grey sand.

3.0 METHODS OF ANALYSIS

The following section describes the method of study followed in the investigation.

3.1 Borehole Drilling

The location of on-site buried services and utilities were established during the afternoon of April 25, 1988 at a joint site meeting. A total of five boreholes were drilled on the site from April 26 to 28, 1988, by All-Terrain Drilling Ltd. The tire mounted CME 75 drill rig used split spoon sampling, and standard penetration testing to provide information for borehole logging which was carried out by senior and intermediate WESA staff. Samples were collected, sealed, labelled and stored.

3.2 Health and Safety

Since there were no accurate records of the substances disposed of in the landfill, care was taken to ensure that workers were not exposed to potentially hazardous contamination and to prevent them from inadvertently carrying toxic substances off the site on clothing or equipment.

A photo-ionization detector HNU # PI102 and combustible gas meter (ENMET # GC10) were used frequently to monitor the split spoon samples and auger cuttings and inside the hollow stem augers. Disposable Tyvek coveralls and plastic gloves were worn while drilling and removed when the workers left the site.

Air purifying respirators and protective goggles were available to all personnel if the PID or combustible gas meter detected the presence of hydrocarbons or combustible gases in the air. A powered air purifier was also available in case an emergency situation arose. In fact, gases were detected only

once, at the third methane well (M3) (combustible gases were measured at >20% LEL).

In the event that high levels of contamination were encountered, workers were prepared to follow the MOE "Occupational Health Protocol" (October 23, 1977).

Hard hats and steel toe, steel shank safety boots were worn at all times during the drilling investigations.

3.3 Borehole Instrumentation

Four boreholes were instrumented as piezometers, with multilevels installed in 3 of the 4 locations. The remaining borehole was instrumented as a gas probe.

Piezometers were constructed with 31.8 mm (1 1/4 inch) schedule 40 PVC pipe, connected with press fit PVC joints and finished with 10 slot PVC screen. An exception exists at P2-2 where 126 mm (1/2") polyethylene tubing was used for the shallow piezometer point. No glue or solvents were used in any of the installations. Our experience at the Gloucester landfill site (WESA, 1986, Devlin, 1987) indicates that PVC and polyethylene piezometers can be employed for reconnaissance organic testing provided that proper sampling protocols are used. In the 3 multilevel piezometer installations, the deepest piezometers were labelled with a suffix of 1 (ie. P3-1) and the more shallow as P3-2 as per standard convention. A vadose zone monitor tube or gas probe was also installed above the groundwater table as described below.

Methane gas probes were constructed of 126 mm (1/2") polyethylene tubing with slotted polyethylene tips wrapped with 210 nytex screen. Up to three tips were installed in each installation at 30 cm intervals to ensure that the gas was sampled immediately above the groundwater table.

All installations were finished at grade and protected with locking caps in order to minimize interference with the park activities.

Locations of the installations are shown in Figure 3. Borehole logs showing details of each installation are found in Appendix C.

3.4 Physical Hydrogeology Monitoring

Physical hydrogeology monitoring was completed in order to target areas for geochemical sampling and to determine the site groundwater flow characteristics. Water levels were obtained in all piezometers which were subsequently surveyed and tied into elevation contours. This information, along with the

drill logs, was tied to a relative datum, in order to define the general three dimensional site hydrostratigraphy.

3.5 Geochemical Sampling and Field Monitoring

3.5.1 Groundwater Samples

Wells were developed by removing a minimum of 5-6 pore volumes prior to sampling. Point P2-2 had a very low yield and had only 2 to 3 pore volumes removed prior to sampling. In addition, field measurements and lab analyses of certain parameters were omitted at this point.

Temperature, conductivity, pH and dissolved oxygen were measured in the field during sampling. Sample bottles were rinsed (except for phenol bottles, which were pretreated), filled to the top, tightly capped without headspace and stored on ice at a temperature below 4° C. Table 1 outlines the samples obtained and the protocols followed during sampling.

TABLE 1: Sampling Protocols

Parameter	Sample Volume	Bottle Type	Pretreatment/ Field Treatment
Metals	125 ml	Polyethylene	Filtered with a 0.45 micrometer millipore filter and acidified in the field
Anions, non-metal cations, COD	125 ml	Polyethylene	None
Phenols	250 ml	Amber Glass	Pretreated with $\text{CuSO}_4 \cdot \text{H}_2\text{O}$ and H_3PO_4
Volatile Organics	100 ml	Amber Glass	Teflon septa lined caps
Extractable Organics	1000 ml	Amber Glass	Aluminum foil lined caps

Dedicated sampling tubes were used at each point sampled. Filtering equipment and tubing associated with the peristaltic pump used to extract the sample were cleaned with nitric acid, methanol and distilled water after each sampling point to prevent cross-contamination.

Inorganic Parameters

Groundwater samples were obtained from the six monitoring locations and were delivered to Dr. John Poland of Queen's University in Kingston for inorganic analysis. Dr. Poland's laboratory was able to provide results on index parameters within 48 hours of sample delivery. These parameters were evaluated with field measurements and physical hydrogeological monitoring in order to choose the monitoring points for organic analyses.

The following inorganic parameters were analyzed:

TABLE 2: Details of Sample Parameters

Field Measurements	Lab Analyses
--------------------	--------------

Conductivity	Fe	NO ₃ -N
Temperature	Mn	NH ₃ -N
Dissolved Oxygen	COD	SO ₄
pH	Alkalinity	Ca
	Phenols	Mg
	Cl	K
		Na

The field monitoring and laboratory analytical reports are contained in Appendix D.

Organic Parameters

Samples for organic analyses were collected at all monitoring points. Based on the results of the phenols, iron, COD, chloride and field measured conductivity, temperature, pH and dissolved oxygen, samples were selected for the actual organic analysis.

In keeping with concerns of the MOE, samples from two selected groundwater monitoring points were delivered to Novalab of Lachine, Quebec, for analysis. Since the exact nature of any possible leachate was not known, a complete U.S. Environmental Protection Agency (USEPA) priority pollutant scan for organics (USEPA Methods 624 and 625) was performed on each sample submitted.

The analytical reports for the organic analyses are found in Appendix E.

3.5.2 Surface Water Samples

Two samples for inorganic analysis were obtained from Marsh Creek for the full suite of inorganic analyses: one immediately upstream of the site and the second close to the point that the creek leaves the site. Field measurements at these locations included temperature, conductivity, pH and dissolved oxygen. The samples were obtained using the same protocol as that used with the groundwater samples with the addition of a 1000 ml untreated BOD sample taken in an amber glass bottle. Surface water samples were taken at approximately 0.50 m depth and less than 1 m offshore at locations shown on Figure 3. Analyses for COD were not performed on surface water samples.

In order to evaluate the impact of the sewage treatment plant outfall on Marsh Creek, surface water was sampled above and below the plant's outfall and the samples, taken in September, 1988, were analysed for nitrate and ammonia.

When organic compounds were found in the groundwater, it was decided that Marsh Creek should be sampled for volatile organic compounds identified in the groundwater. Analyses for extractable organic compounds were not carried out since only low levels of extractable compounds were found in the groundwater, with the exception of phenols. Phenols were included in the 'inorganic' suite of analyses and were not detected in Marsh Creek (Table 5).

3.5.3 Seepage Meter Samples

Two seepage meters were installed in the bottom of Marsh Creek, as described in Lee and Cherry (1978). Both meters were installed in areas that appeared to have leachate discharging from the creek bank. Samples were taken from the plastic sample bag attached to the outlet tubing. No water was recovered from the upstream seepage meter (located on Figure 3).

Seepage meter samples probably contain both groundwater and surface water. The resulting geochemical analyses may be used in a qualitative sense for parameter identification, but requires extensive multipoint interval sampling to be used in a quantitative sense. The samples do not strictly refer to either ground or surface water. Field chemistry measurements were not made on seepage meter samples due to low sample volume. Parameters analyzed on the seepage meter samples included iron, manganese, BOD, alkalinity, phenols, chloride, nitrate, sulphate, ammonia, calcium, magnesium, potassium and sodium. The results of field monitoring and inorganic analyses are found in Appendix D.

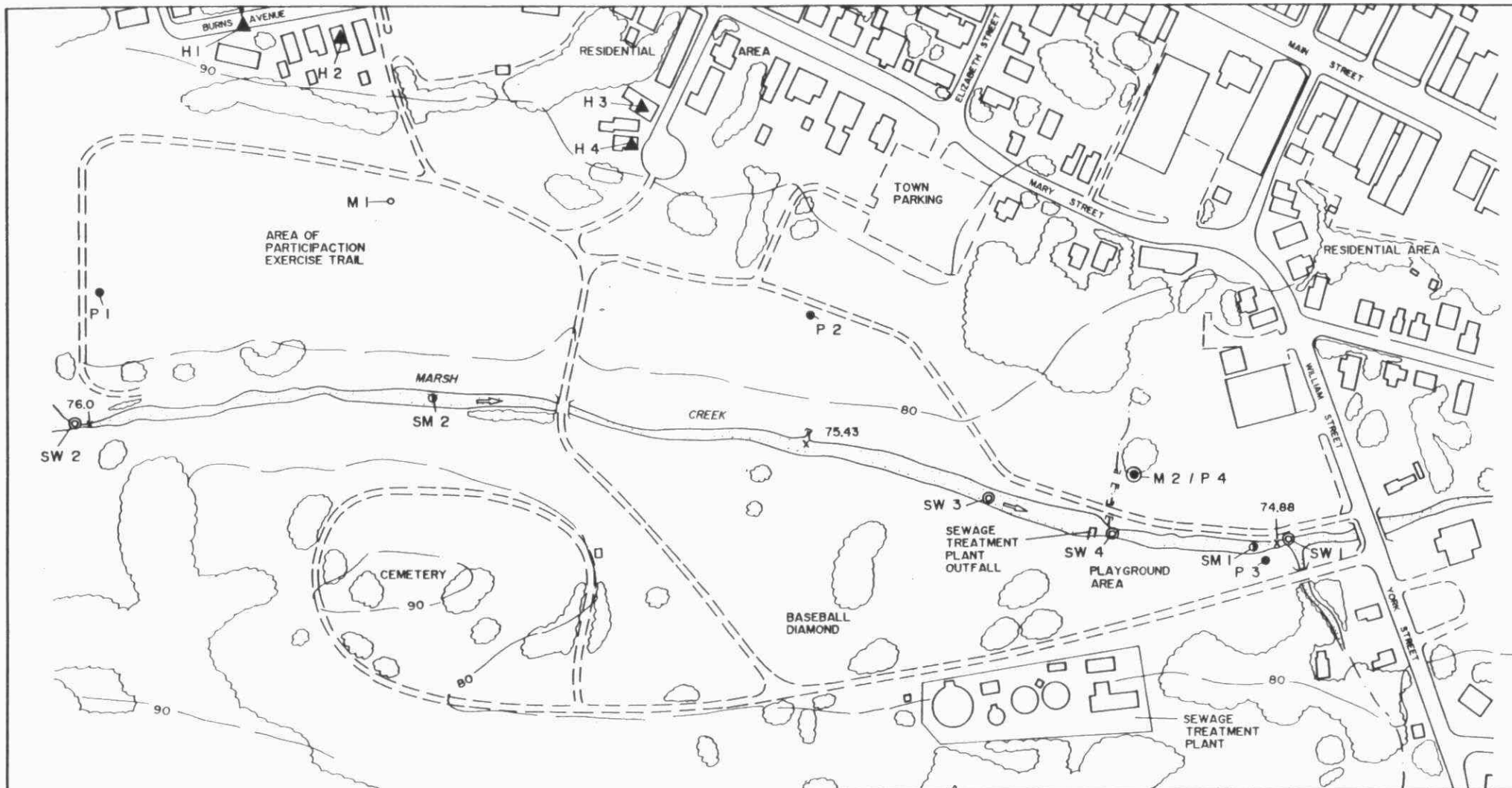


FIGURE 3
INSTALLATION LOCATIONS AND
PRESENT LAND USE

DELHI PARK LANDFILL SITE,
PICTON, ONTARIO.



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3.5.4 Quality Assurance/Quality Control

Results from analysis of blank and duplicate samples are included as Appendix F.

All field equipment, including pH, conductivity, dissolved oxygen and the methane gas detectors, was calibrated under in-situ conditions to ensure the gathering of reliable, quality data.

3.6 Gas Monitoring

An Enmet GCIO combustible gas detector was used to monitor all installations for methane. The Enmet GCIO can be used to detect combustible gases specifically up to 20% of the lower explosive limit (the lower explosive limit of methane is 5% methane gas by volume). Thus the highest concentration measurable by the Enmet meter, 20% of the lower explosive limit, is equivalent to 1% CH₄ gas by volume.

A tube was attached directly to the 1/2" polyethylene tubing of the gas probes. Gases were then pumped with a squeeze bulb directly from the well to the meter.

The Enmet meter was also used to monitor four basements in homes judged to be the most susceptible to landfill generated combustible gas build-up due to the landfill (located on Figure 3).

4.0 RESULTS

The results of the investigation are documented following and will be discussed further in Section 5.0.

4.1 Physical Hydrology Monitoring Results

Table 3 shows the results from the location survey and from the water level monitoring.

Groundwater at any point flows in the direction of decreased hydraulic head. Hydraulic gradients, calculated as the change in hydraulic head divided by the distance between two points is a measure of the driving force behind the groundwater flow. Groundwater velocity can be calculated as the product of the hydraulic gradient and hydraulic conductivity (a function of the material through which the groundwater is flowing).

Table 4A shows hydraulic gradients calculated vertically between two monitoring points in a single multi-level installation. Horizontal gradients between P1 and P2 are calculated in Table 4B. Horizontal gradients between P3 and the

TABLE 3: PHYSICAL HYDROLOGY MONITORING RESULTS
DELHI PARK LANDFILL, PICTON

		P1-1	P1-2	P2-1	P2-2	P3-1	P3-2	P4
A.	SURFACE ELEVATION (# A.S.L.)	80.90	80.90	81.44	81.44	76.42	76.42	76.74
B.	INSTALLATION DEPTH (#)	23.15	6.40	28.65	7.31	9.14	4.57	2.43
C.	ELEVATION OF SCREEN BOTTOM (A-B, # A.S.L.)	57.75	74.50	52.79	74.13	67.28	71.85	74.31
D.	STATIC WATER LEVEL (# BELOW GROUND)	3.64	3.64	4.93	5.24	0.72	0.91	1.00
E.	PRESSURE HEAD (B-D, # A.S.L.)	19.51	2.76	23.72	2.07	8.42	3.66	1.43
F.	HYDRAULIC HEAD (C+E, #)	77.26	77.26	76.51	76.21	75.70	75.51	75.74
G.	BEDROCK ELEVATION (# A.S.L.)	57.74	57.74	52.79	52.79	67.28	67.28	---

TABLE 4A: VERTICAL HYDRAULIC GRADIENTS IN MULTI-LEVEL INSTALLATIONS
DELHI PARK LANDFILL, PICTON

FROM (1)	TO (2)	h(1) (m)	h(2) (m)	h(1)-h(2) (m)	d (m)	$\frac{h(1)-h(2)}{d}$
P1-1	P2-1	77.26	77.26	0.00	16.77	0.000
P2-1	P2-2	76.51	76.21	0.30	21.34	0.014 upwards
P3-1	P3-2	75.70	75.51	0.19	4.57	0.042 upwards

TABLE 4B: APPROXIMATE HORIZONTAL HYDRAULIC GRADIENTS ALONG THE
BEDROCK SURFACE

FROM (1)	TO (2)	h(1) (m)	h(2) (m)	h(1)-h(2) (m)	d (m)	$\frac{h(1)-h(2)}{d}$
P1-1	P2-1	77.26	76.51	0.75	154	0.005 towards P2
P1-2	P2-2	77.26	76.21	1.05	154	0.007 towards P2
P2-1	P4-1	76.51	75.74	0.77	79	0.010 towards P4

other two installations across Marsh Creek were not calculated since the Marsh Creek likely represents a flow boundary.

Vertical hydraulic gradients in two of the multilevels (P2 and P3) indicate there is an upward component to groundwater flow at these locations. The vertical hydraulic gradient in P1, on the flank of the slope is nil, suggesting groundwater flow is generally horizontal at that point. All horizontal hydraulic gradients (Table 4B) indicate that the water is flowing towards Marsh Creek and Picton Bay which act as discharge areas for Delhi Park.

It is very difficult to assign a hydraulic conductivity value to a material as heterogeneous and anisotropic as landfilled waste. Based on the fact that small volumes were recovered in split spoon samples of the refuse and that any geologic material recovered in the waste during drilling was generally sandy with gravel or boulders, a relatively high hydraulic conductivity might be expected. A representative range of 10^{-3} to 10^{-5} m/s is assumed in this case in order to make rough calculations. These values correspond to a range of geologic materials from clean sand to silty sand (Freeze and Cherry, 1979) and are also a representative range for the sand underlying the waste in all holes drilled. If these values are correct, they correspond to shallow groundwater flow velocities from P2 towards P4 and from P1 towards P2 in the range of 0.1 to 300 m/year. This suggests that infiltrated water may flush through the landfill relatively quickly before being discharged into the Marsh Creek and its environs.

The level of water in Marsh Creek varied between 74.88 and 76.0 in May, 1988.

4.2 Inorganic Chemistry and Field Monitoring Results

Table 5 contains the results from field monitoring and inorganic chemical analysis.

Also included in Table 5 are the Ontario Drinking Water Objectives (revised by the MOE in 1984) and representative ranges for inorganic parameters in leachate from sanitary landfills (Freeze and Cherry, 1979).

4.3 Organic Chemistry Results

Results from the USEPA 624 volatile and the USEPA 625 extractable analyses are included in Table 6. The two groundwater sampling points (P1-2 and P3-2) were chosen for organic analysis on the basis of the following points:

TABLE 5: FIELD MONITORING AND INORGANIC CHEMISTRY RESULTS
DELHI LANDFILL, PICTON

	GROUNDWATER SAMPLES							SEEPAGE METER SAMPLE	SURFACE WATER SAMPLES				DNT. DRINKING RANGES IN LEACHATE WATER FROM SANITARY LANDFILLS (FREEZE & CHERRY 1979) OBJECTIVES (REVISED 1983)	
	P1-1	P1-2	P2-1	P2-2	P3-1	P3-2	P4	SM1	SW1	SW2	SW3	SW4		
FIELD MONITORING														
Conductivity (uS/cm)	412	1150	1120	--	485	2580	550	--	460	360			--	--
Temperature (oC)	13	13	13	15*	12.5	11	10	--	18.5	20.0			--	15
Dissolved Oxygen (ppm)	7.1	5.4	10.0	--	7.0	7.6	5.5	--	10.4	11.3			--	--
pH	7.15	6.45	6.95	--	7.00	6.9	6.9	--	6.9	7.75			--	4-8
INORGANIC CHEMISTRY RESULTS														
Fe (ppm)	<0.10	11.1	0.60	61.0	<0.10	<0.10	11.2	<0.10	<0.10	<0.10			0.3	1-1,000
Mn (ppm)	0.09	2.85	0.09	0.54	0.08	1.40	0.08	<0.05	<0.08	0.23			0.05	0.01-100
COD (ppm)++	<3	154	<3	220	<3	6	27	<5	<5	<5			--	1,000-90,000
Alkalinity (ppm)	318	1030	296	--	285	483	291	502	209	230			--	500-10,000
Phenols (ppb)	<1.0	143	<1.0	--	<1.0	<1.0	3.0	<2	<1.0	<1.0			2.0	--
Chloride (ppm)	81	131	718	29	140	125	142	166	56	7.3			250	300-3,000
Nitrate-N (ppm)	<1	<1	<1	5.0	<1	<1	<1	<1	5.0	<1	8.82	0.54	10.0	0.1-10
Sulphate (ppm)	29	28	9	309	9	25	<2	<2	59	5			500	10-1,000
Ammonia-N (ppm)	<0.10	19	0.47	<0.10	0.12	0.13	8.5	14	3.3	<0.10	4.62	1.38	--	100-3,000
Calcium (ppm)	94	282	136	--	89	170	83	143	74	80			--	100-1,500
Magnesium (ppm)	23	37	46	--	35	40	13	41	7.9	7.5			--	200-1,000
Potassium (ppm)	6.3	30	11.5	--	3.8	2.7	10.8	2.8	7.1	2.0			--	200-1,200
Sodium (ppm)	56	90	460	--	45	34	68	37	39	13			--	200-1200
Calculated Hardness(ppm)	329	857	529	--	366	589	261	526	217	231			--	660-13,650

* Poor sample, small volume

++ BOD was measured on surface water samples

TABLE 6: Organic Chemistry Results, Delhi Park Landfill, Picton

	P1-2	P3-2	SW1	SW3	DWO*	MDL**
VOLATILE PRIORITY POLLUANT (ug/l)						
Benzene	4.5	-	-	-	10	1
Chlorobenzene	3	-	-	-	60***	1
Chloroform	9.7	-	3.5	-	350	1
1,2-Dichlorobenzene	-	-	1.3	-		1
1,1-Dichloroethylene	2.8	-	-	-	7	1
1,1-Dichloroethane	7.9	-	-	-		1
Dichloromethane	-	-	12	-		10
Ethylbenzene	12	-	-	-		1
Tetrachlorethylene	1	-	7.6	3.4	10	1
Toluene	5.2	-	-	-	2000	2
1,1,1 - Trichloroethane	-	-	trace	-	200	1
Trichlorofluoromethane	540	-	-	-		1
M+P-Xylene	77	-	-	-		2
O-Xylene	7.8	-	-	-		1
Other Aromatic Compounds	140	-	-	-		1
BASE/NEUTRAL PRIORITY POLLUTANTS (ug/L)						
BIS(2-Ethylexyl)Phthalate	1.2	-	n/a	n/a		1
DI-N-Buthyl Phthalate	3.9	4.5	n/a	n/a		1
1,4-Dichlorobenzene	1.2	-	n/a	n/a		1
Diethyl Phthalate	2	-	n/a	n/a		1
Napthalene	3	-	n/a	n/a		1
ACIDIC PRIORITY POLLUTANTS (ug/L)						
Phenol	73	-	n/a	n/a	2	1

NOTE: Only those compounds with detectable concentrations are included in the table. A complete listing of the EPA 625 and 624 compounds analyzed are included in Appendix E.

* Drinking Water Objective (WESA, 1988)

** Method Detection Limit

*** US EPA Limit

- i) the highest conductivity values were found in these two points (the highest conductivity obtained was 2580 uS/cm in P3-2),
- ii) the phenol level in P1-2 (143 ppb) was the highest measured in the study,
- iii) high chloride and alkalinity levels were measured in both points,
- iv) the physical hydrology monitoring indicated that P3 was the furthest downgradient piezometer.

Two samples from Marsh Creek were analysed for USEPA Volatile Priority Pollutants. One sample was taken from above the sewage plant outfall in Marsh Creek (SW3) and the second from below (SW1).

4.4 Gas Monitoring Results

The results of the gas monitoring are contained in Table 7.

TABLE 7: Methane Gas Monitoring Results,
Delhi Park Landfill, Picton

Gas Probe	%LEL	Equivalent %CH ₄ by volume*
P1	>20	>1
P2	>20	>1
P3	>20	>1
M2/P4	10	0.5
M1	>20	>1
H1	Nil	Nil
H2	Nil	Nil
H3	Nil	Nil
H4	Nil	Nil

* The lower explosive limit is reached at 5% CH₄ by volume.

No combustible gases were detected in any of the four basements monitored.

5.0 DISCUSSION

5.1 Physical Hydrogeology

A comparison of bedrock and surface elevations of the four piezometer installations with their locations (Figure 3) indicates that both the bedrock and surface topography slope towards Marsh Creek and Picton Bay. Creeks surrounded by topographically high areas are usually characterized by flow regimes consisting of recharge from the high areas, groundwater flow towards the creek, and discharge into the creek and its vicinity. In the case of Marsh Creek, which outlets into Picton Bay less than one kilometre downstream of the landfill site, a downstream gradient towards Picton Bay is superimposed on the local flow regime.

Horizontal hydraulic gradients (Tables 3 and 4) confirm that the shallow groundwater is flowing towards Marsh Creek and Picton Bay. Hydraulic head values are highest in P1 (which is the furthest from Picton Bay) and lowest in P3.

Vertical hydraulic gradients indicate that the landfill is located in a discharge area. Given this situation, any contaminants generated by the landfill and entrained in the local groundwater flow regime will ultimately discharge into Marsh Creek. It is unlikely that contamination of deeper aquifers is occurring.

5.2 Inorganic Chemistry and Field Monitoring

5.2.1 Groundwater

A brief comparison of the contents of Table 5 with the representative ranges of the inorganic constituents in leachate from sanitary landfills (Freeze & Cherry, 1979) indicates that the leachate at Delhi Park Landfill has relatively low concentrations of most parameters.

Conductivity values measured in the field varied from 412 to 2580 us/cm with the highest values recorded in P1-2 and P3-2.

Groundwater temperature ranged from 10 to 15° C which is slightly higher than usually found in shallow groundwater. Chemical and biological activity in the landfill material may be generating some heat, causing the groundwater temperature to increase.

Dissolved oxygen concentrations ranged from 5.4 to 10.0 ppm indicating that relatively high oxygen concentrations are present in the leachate.

Values for pH, ranging from 6.45 to 7.15 are characteristic of leachate.

Iron and manganese levels ranged from below the detection limit to 200 times the drinking water objective values of 0.3 and .05 mg/l respectively. Manganese ranged from 0.08 to 2.85 mg/l and iron from <0.10 to 61.0 mg/l. These metals are common constituents of landfill leachate.

The chemical oxygen demand measured at the site was less than 100 ppm in all points except for P1-2 and P2-2 which had COD's of 154 and 220 ppm. Comparison with the range considered representative for landfill leachates (1000-90,000 ppm) implies that demands are very low. This may indicate that most of the chemical activity associated with degradation of domestic wastes has already occurred. The high dissolved oxygen levels concur with this hypothesis since oxygen is often involved in and used up by degradation reactions.

Alkalinity values, expressed as equivalent CaCO_3 , ranged from 285 ppm in P3-1 to 1030 ppm in P1-2. The levels are moderately high, and also appear to be related to the calculated hardness of the water, suggesting the alkalinity may be related to the limestone bedrock. Dissolved carbon dioxide constituents are the principal sources of alkalinity in most waters. Other non-carbonate contributors to alkalinity include hydroxide, silicate, borate, and organic ligands (especially acetate and propionate).

Phenol concentrations were less than 3 ppb in all wells except P1-2 which had a concentration of 143 ppb. Phenols can occur naturally in swamp or marsh areas such as originally existed at Delhi Park and are also commonly associated with petroleum distillate products. Given its isolated occurrence in this case, it is probable that the phenols in P1-2 are from landfill material.

Chloride levels were above the drinking water objective in only one location (718 mg/l in P2-1). Sulphate levels were below the drinking water objective in all samples. These low levels also suggest that the groundwater is contaminated with relatively low strength leachate.

Detectable nitrate was found only in P2-2 at a level of 5.0 ppm. Ammonia is commonly associated with domestic waste, exhibiting values ranging from <0.10 to 19 ppm. These values correlate to the lower range of ammonia concentrations found in landfill leachates.

Calcium values, ranging from 83 to 282 mg/l, are moderately high, contributing to the hardness of the water. Magnesium ranges from 13 to 46 ppm and potassium from 2.7 to 30 ppm. These are considerably lower than calcium levels and are well below the range of representative concentrations for landfill leachate listed in Table 5. Sodium levels (34 to 460 mg/l) are also below the representative range found in leachate with the exception of a value of 460 mg/l measured in P2-1.

In summary, while common leachate constituents (ie. Fe, Mn, Cl, NH₃, Ca, Na) are elevated, they are all below or in the lower representative ranges for leachate in sanitary landfills included in Table 5. The relatively low strength of the leachate may be due to several factors:

- 1) the shallow depth of the landfill (approximately 3-6 m) effectively minimizes the depth of refuse through which water infiltrates.
- 2) Delhi Park is located in a discharge zone with relatively high groundwater flow. Thus any water reaching the site is discharged into Marsh Creek and its environs soon afterward, limiting the amount of contaminant leaching that can occur. The process also effectively flushes leachate constituents into Marsh Creek, with progressively lower strength leachate occurring in time.

In the process of flushing, chloride, being one of the most mobile leachate constituents, is usually the first to arrive at a downgradient sampling point and the first to experience a decay in strength once the source is depleted. Parameters which are progressively more retarded arrive later and may persist longer.

From the physical hydrogeology we know that groundwater is flowing towards Marsh Creek and Picton Bay. While P1 is definitely upgradient of P2, it is difficult to say whether groundwater flows from P1 past P2 or whether it flows into Marsh Creek. Marsh Creek and the Picton Fault zone separate P3 from P2 and P1. Thus it is difficult to assign up- or downgradient attributes to any of the installations. In fact, no clear trend between piezometers is visible in the inorganic parameters. It is difficult to draw conclusions with respect to the contaminant plume migration and source functions based on these results.

Generally, higher concentrations of inorganic parameters are recorded in the upper level of the multilevel installations (i.e. iron, manganese, chemical oxygen demand, alkalinity, phenols, nitrate, calcium, magnesium and calculated hardness). The higher levels in the shallow sampling points are certainly associated with groundwater contamination by the landfill leachate.

Exceptions where higher levels of some parameters are found in the deeper sampling point exist in P2 (where chloride and ammonia levels are higher in the deeper level) and P3 (where chloride, potassium and sodium are higher in the deeper point). These parameters, although associated with landfill leachate, are also present in the natural environment and more likely to constitute discharge from a deeper more mineralized groundwater found in the local bedrock. With the exception of the ammonia, the parameters are commonly found in natural systems.

Given the measured hydraulic gradients and the landfill location in a discharge area, it is unlikely that the shallow, leachate contaminated groundwater penetrates below the overburden.

5.2.2 Seepage Meter

Samples were recovered from the downstream seepage meter, located near P3. A seepage face on the creek bank appeared to be discharging a reddish-coloured liquid, probably associated with red building material detritus recorded in the well log for P3 (Appendix C). The low concentration of iron in the sample (<0.10 ppm) indicates that iron is not a soluble component of the building detritus. The seepage meter and P3-2 samples had similar levels of all parameters except manganese, sulphate and ammonia. Given that the two sampling points (P3-2 and the seepage meter) are an estimated 4 to 5 meters apart, good correlation exists between their chemistries and the values measured in the seepage meter are representative of the leachate that is being discharged into Marsh Creek (Sections 5.1, 5.2).

5.2.3 Surface Water

The contaminant concentrations measured in the surface water samples were all within the MOE surface water quality objectives (or drinking water objectives where surface water objectives do not exist) except for manganese. Manganese concentrations of <0.08 and 0.23 mg/L were found. The drinking water objective is 0.05 mg/L. There is a detectable change in the water quality of the creek between the upstream and downstream samples (SW2 and SW1 respectively). Levels of conductivity, chloride, nitrate, sulphate, ammonia, magnesium, potassium and sodium increase in the creek as it traverses the

site. The slight decreases in calcium, manganese, alkalinity and pH are probably related.

The increase in nitrogen species concentration obtained from samples taken above and below the sewage treatment plant outfall in September, 1988, show that nitrate and ammonia are being contributed to the creek at the outfall. Nitrate increased from 0.54 to 8.82 mg/l (as N) and ammonia from 1.38 to 4.62 mg/l (as N). Possible contributions attributed to the landfill would appear to be negligible in comparison to these values.

The surface water quality of Marsh Creek appears to have improved since the MOE sampling in 1977. Alkalinity, iron, chloride, conductivity and sulphate were all significantly lower in the 1988 analyses. Samples taken in 1988, however, show that significant temporal variations of contaminant concentrations in the creek occur. For example, nitrate levels of 0.54 and 8.82 mg/l as N were measured in September, 1988 while no nitrate was detected in May. These fluctuations illustrate the limitations of 'one time' or sporadic sampling events and may be due to the quality and quantity of the outfall from the sewage treatment plant.

5.3 Organic Chemistry

5.3.1 Groundwater

Volatile Priority Pollutants

Measurable levels of twelve volatile compounds were identified in the sample from P1-2 analyzed for USEPA priority pollutants at the Delhi Park Landfill site. It should be noted that drinking water objectives have not been set for most organic compounds. No detectable volatile organics were found in the sample from P3-2, which was completed in the oldest section of the landfill.

Benzene, ethylbenzene, toluene and xylenes (BTXE) are common constituents of petroleum (both naturally occurring hydrocarbons and refined products). Levels found in the investigation are relatively low (<10 ppb), except for a level of 77 ppb of M+P xylene in P1-2.

Naturally occurring BTXE can be found in bedrock in the Belleville area at concentrations as high as 100 ppb (pers. comm. Mr. John Tooley, Abatement Section, MOE, Belleville). The Verulam Formation, a petroliferous interbedded limestone and shale, underlies both the Belleville site studied and the Picton site east of the Picton Fault zone. Thus the low concentrations

measured at the Delhi Park Landfill may be attributed to either natural or landfill sources.

Halogenated compounds, such as chlorobenzene, 1,1-dichloroethylene, and 1,1-dichloroethane are not likely to be in the background groundwater and indicate landfill related contamination.

Chloroform, found at 9.7 ppb in P1-2, is a widely used industrial and laboratory solvent. The level is well below the drinking water level (350 ppb) and can be a product of water chlorination.

Tetrachloroethylene, found very near the method detection limit, is a solvent primarily used in dry cleaning. Its source is probably related to the landfill.

Trichlorofluoromethane was found at a moderately high level of 540 ppb in P1-2. Industrial uses of this compound include freons used in refrigeration, propellents in aerosols, and solvents in fire extinguishers. The moderately high levels are probably from landfill materials.

Relatively high levels of "Other Aromatic Compounds" or aromatic compounds which are not included as USEPA priority pollutants, were found in P1-2 (140 ppb). These could include a variety of compounds, such as trimethylbenzene.

Extractable Priority Pollutants

Seven extractable organic compounds were found in the samples submitted for analysis.

Phthalates are ubiquitous in groundwater at low levels and can also be present in sampling and/or laboratory equipment. They are common in routine extractable organic analyses. They are present at levels very close to their detection limits.

The presence of 1,4-Dichlorobenzene is probably related to the halogenated compounds found in the volatile organic analyses. As discussed in Section 5.3.1, their presence may be from the landfill. The levels are extremely low (1.2 ppb) and barely exceed the method detection limit (1 ppb).

Naphthalene is a polycyclic aromatic hydrocarbon. The low level of 3 ppb is not unusual and is probably associated with the landfill. Naphthalene is commonly associated with products and by-products of the wood preservative industry and may be found in association with refined and unrefined petroleum and coal tar wastes.

Phenol was reported only in P1-2 in the EPA analyses at a level of 73 ppb. The level is significantly lower than that found in Table 5, which was analyzed by a colourmetric method (the 4-aminoantipyrene method). This is probably because the USEPA scans include only specific phenol compounds whereas the colourmetric method includes both phenol and phenolic-like compounds. The phenol level is quite high in this sampling point. It's origin is likely landfill related given its isolated occurrence.

Both industrial and domestic waste may be responsible for the organic pollutants discussed above. The sources of the low level organic contaminants most likely include industries in the Picton area (ie. plastics manufacture, machine work, tool and die manufacture and electronic and small appliance assembly). The levels in the groundwater were non-existent at P3-2 and close to the detection limit in most instances in P1-2. Although they are not naturally occurring, their release to the environment of concern, their generally low levels and limited distribution suggest they do not pose a significant environmental risk.

5.3.2 Surface Water

Marsh Creek was sampled in order to determine if the organic compounds found in the groundwater were impacting the surface water. The creek was sampled for USEPA Volatile Priority Pollutants. Extractable compounds were not sampled for since only low levels of extractable compounds were found in the groundwater (with the exception of phenols which are included in the 'inorganic' suite of analyses and were not detected in the creek water).

The creek was sampled above and below the sewage treatment plant outfall on September 29, 1988. Sample SW1 (below the outfall) was analysed first to determine whether or not organics were present in the creek at the point where it left the site. Sample SW3 (taken above the sewage treatment plant outfall) was analyzed to eliminate possible contributions from the outfall after volatile organic compounds were detected in SW1.

The results (Table 6) indicate that slightly higher concentrations were found below the sewage treatment outfall than above (the highest concentration measured was 12 ug/l of dichloromethane). Minor volatilization or biodegradation of volatile constituents may have occurred between the two dates of analysis (6 days). However, work by Devlin, 1987, would suggest that sample storage of less than a week would only have a minor impact. The decline does appear to have the greatest impact on the concentrations of the most volatile constituents.

The presence of low concentrations of volatile organic compounds in SW3 confirms that some of the organic contamination present in the creek is probably due to the landfill. As seen in section 5.2.3, concentrations in the creek can fluctuate with time and 'one-time' sampling events are limited in this respect.

The levels recorded are all below drinking water objectives. Based on these levels, potential impacts of organic compounds derived from leachate emanating from the landfill site are likely unmeasurable in Picton Bay. Significant biodegradation, volatilization and overall renovation of water quality downstream are predicted, reducing recorded concentrations to below detection limit. The impact on Picton Bay after degradation and dilution are considered to be negligible. Other contaminant inputs, including wash-off from streets and the urban area in general, are likely of a greater concern.

5.4 Gas Monitoring

Combustible gases are presently being generated at the Delhi Park Landfill and were detected in all gas probes installed. Levels in 4 out of 5 of the gas probes installed directly into the waste material had greater than 1% combustible gas by volume. The maximum level recorded on the meter is equivalent to one-fifth the concentration required to reach an explosive level. The fifth well, installed in the older part of the landfill, had 0.5% combustible gas reading.

Houses near the landfill are located on the top of a 8-10 m rise making the migration of combustible gases into their basements unlikely. The basements of four homes judged to be the most susceptible to combustible gas buildup originating from the landfill were sampled using the Enmet meter. No combustibles were detected.

Gas migration characteristics, may vary seasonally due to frost or percolating groundwater. In order to fully evaluate the risk of gas build-up in basements, it may be advisable to monitor the gas probes in the late winter months while frost is still in the ground. However, given the age of the site and the absence of reported incident to date, the potential for gas buildup in existing structures appears to be low.

If new buildings closer to the site are to be constructed, adequate monitoring and remedial gas venting work should be incorporated in design and construction.

6.0 CONCLUSIONS

The following conclusions are drawn from the hydrogeological study presented. They are based on current standards and recognized procedures and are limited to the data available during the course of the study.

1. The inorganic leachate characteristics are typical of low strength landfill leachate. Measurable levels of 16 different organic compounds were found in the leachate. While some of the compounds may be from natural sources, the majority of them are attributed to the landfill. Unidentified industrial waste was almost certainly disposed of at the site.
2. Low levels of volatile organic compounds from the landfill are impacting Marsh Creek which outlets into Picton Bay. Significant organic contamination of Marsh Creek was not measured during the study. Although no compounds were measured above the drinking water objectives, concentrations in the creek fluctuate temporally and seasonally, and a 'one-time' sampling event cannot fully describe the concentrations and distribution of organic compounds.

Inorganic water quality is also impacted by landfill leachate entering Marsh Creek as it traverses the site. The seepage meters and the groundwater flow regime (as measured by the piezometers installed at the site) confirm that leachate generated on the site is most likely being discharged into the creek. Samples taken above and below the sewage treatment plant outfall indicate that both the landfill and the sewage treatment outfall are degrading the inorganic water quality. The degradation of water quality in Marsh Creek is not severe, however, and no constituents measured were above the drinking water objectives with the exception of manganese.

The impact on the water quality of Picton Bay due to the landfill site is deemed negligible from both organic and inorganic parameter perspectives. This statement is based on the fact that the concentrations of most constituents (except manganese) measured on site do not appear at levels in excess of established drinking water objectives in Marsh Creek. Also, dilution and oxidation will significantly lower the recorded manganese concentration in the creek prior to discharge into the Bay.

3. The Delhi Park Landfill is actively generating methane at the present time. Methane levels greater than 1% by volume were measured in four out of five installations. A lower level 0.5% by volume was found in the older area of the landfill where methane generation is probably decreasing.

Residences near the landfill are located on the top of an 8-10 m high bluff and are unlikely to be impacted by methane migration. No methane was detected in four basements monitored.

4. The site's present physical condition is excellent with the exception of Marsh Creek which was observed to have an oily film and areas of scum during periods of low flow. The park is well used by the public and there are no visible clues that the property is an abandoned landfill.

7.0 RECOMMENDATIONS

The following recommendations are made for site improvement with respect to site monitoring. No remedial action is recommended at the present time.

1. The water quality in Marsh Creek (which flows into Picton Bay, the municipal water supply) should be monitored annually. This monitoring should be in addition to regular municipal water supply sampling. It is recommended that a minimum of the following parameters are measured in Marsh Creek at each sampling event.

Inorganic: Iron, Manganese, BOD, Chloride, Nitrate, Ammonia, Sulphate, Conductivity, pH.

Organic: A full suite of EPA 624 and 625 Priority Pollutants.

If the surface water quality is found to vary significantly or degrade, samples should be taken to isolate the contribution of the sewage treatment plant outfall from the landfill. Significant Levels of organic contaminants, if found, will warrant a contingency plan. This should include recognition and removal of the contributing contaminant source, determination of the overall contaminant distribution, containment of the contaminant, removal and/or remedial processes and long term monitoring of the area , should be implemented.

Respectfully submitted,



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8.0 REFERENCES

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APPENDIX A:

INVENTORY OF INDUSTRIES THAT MAY
HAVE LANDFILLED AT DELHI
PARK LANDFILL SITE, PICTON

(information supplied by the Town
of Picton)

INDUSTRY	PRODUCT
AERO MARINE INDUSTRIES LTD.	Specializing in Reinforced Plastics
AIR SHADE AWNINGS	Aluminum Awnings.
J.R. BALL MACHINE WELLINGTON, ONTARIO	Wind Generators - General Machine Work
BATA INDUSTRIES LTD.	Footwear.
BAXTER CANNING CO. LTD.	Canned Vegetables, Juices and other Processed Food Products.
CANADA FANS	Industrial and commercial fans and blowers.
CER-A-MET MANUFACTURING LTD. WELLINGTON, ONTARIO	Investment castings.
K.G. CONLEY & SON LTD. WELLINGTON, ONTARIO	Canned Whole Tomatoes.
COOPER LUMBER LIMITED BLOOMFIELD, ONTARIO	Hardwood & Softwood pallets Hardwood lumber
CRESSY TOOL & DIE LTD.	Jigs, Fixtures and Progressive Dies. Light Metal Stamings.
DASH MARINE LTD.	Yachts.
DIMENSIONS IN CRAFTS INDUSTRIES)	Woven and Knitted products, (ARC Footstools and Benches, Furniture Stripping.
EAST LAKE INDUSTRIES INC.	Industrial Lanbswool Dusters.
C.B. FENNELL LTD. CHERRY VALLEY	Ready Mix Concrete.
HARRISON'S FOODS LTD.	Fresh and Frozen Fish, Frozen Sweet Corn.
W.G. HENLEY FABRICATIONS LTD.	Aluminum and Steel Boats, 14 ft.-45 ft. Trailers, Custom Welding.

HYATT CANNING LTD. VALLEY	Canned Peas, Whole Tomatoes, CHERRY Pumpkin Pie Filling Pork and Beans, Red Kidney Beans and Chick Peas.
ISLAND ENGINEERING & CONSTRUCTION LTD.	Floating Docks.
LAKE ONTARIO CEMENT	Portland Cement (Types 10-20) Masonry Cement/Pronto
NORTONS MACHINE SHOP	Fan Parts and General Machining.
NYE YACHTS BLOOMFIELD, ONTARIO	Fibreglass Sailing Yachts.
PICTON ALL-PINE FURNITURE	Furniture and Accessories.
POWER CONCRETE PRODUCTS (PICTON) LTD.	Ready Mixed Concrete, also Precast: Well Tile and Culvert Tile, 6 in. - 60 in; Well Lids; Manholes, Chimney Caps; Bumper Curbs; Patio Slabs.
PRINCE EDWARD QUARRIES (PICTON) LTD.	Crushed Limestone.
PROCTOR-SILEX CANADA INC.	Small Appliances (Assembly)
QUINTE MEAT PRODUCTS LTD. WELLINGTON, ONTARIO	Pork, Beef, Veal and Lamb Grindroom Production and full line of portion controlled meats.
RUTTER ORCHARDS LTD. BLOOMFIELD, ONTARIO	Frozen Cherries - Industrial and Institutional
SECUTRON LIMITED	Electronic Fire and Security Alarm Devices.
TWI-LITE INDUSTRIES	Wood Caskets.
WAUPOOS CANNING CO. LTD.	Canned Peas, Green and Wax Beans, Whole Pack Tomatoes, Stewed Tomatoes and Tomato Paste.
WELLINGTON MUSHROOM FARM WELLINGTON	Mushrooms, Boxed and Bulk.
WIGHT MILLING LIMITED BLOOMFIELD, ONTARIO	Poultry Feed, Cattle Feed, Pig Feed.
WINGRILL INC.	Wooden Window Grills.

CALTEX

Head Harness for Gas Masks.

RAY EALEY MANUFACTURING

KISS Marine Refrigerators - air cooled and water cooled - for all types of pleasure craft.

PRINCE EDWARD TUG AND
BARGE CO. LTD.

Small harbour diesel tugs, small barges and retail marine equipment.

APPENDIX B:

RESULTS FROM M.O.E. SAMPLING OF
MARSH CREEK, 1971 AND 1977

RESULTS FROM M.O.E. SAMPLING OF MARSH CREEK, PICTON

1971

SAMPLE LOCATIONS:MOE LAB NO.LOCATION

R28-139	Marsh Creek upstream of dump (from DND)
R28-140	Marsh Creek upstream of dump at cemetery
R28-141	Marsh Creek centre of dump
R28-142	Marsh Creek upstream of sewage treatment plant outfall
R28-143	Marsh Creek downstream of sewage treatment plant outfall
R28-144	Picton Bay at Bridge Street

RESULTS (ppm)

	<u>TOTAL SOLIDS</u>	<u>TOTAL SUSPENDED SOLIDS</u>	<u>TOTAL DISSOLVED SOLIDS</u>	<u>NH₃</u>	<u>TKN</u>	<u>NO₂</u>	<u>NO₃</u>	<u>TOTAL P</u>	<u>SOLID P</u>	<u>BOD</u>
R28-139	520	5	515	0.4*	.35*	.038*	2.6*	0.054*	.008*	1.0
R28-140	360	20	340	<.01	.40	.039	0.25	.22	.056	0.6
R28-141	560	60	500	.78	1.1	1.3	1.5	.25	.006	4.0
R28-142	730	50	680	.15	3.8	.16	.23	.33	.009	7.0
R28-143	500	20	480	.25	3.4	.26*	*	*	.015	5.0
R28-144	320	10	310	0.2	1.9	1.6	2.4	2.0	1.4	6.0

*Sample exhausted

1977

SAMPLE LOCATIONS:MOE LAB NO.LOCATION

KW 27-1 through 8

Marsh Creek through Picton Landfill

KW 32-59

Storm sewer at Picton Landfill

KW 32-60 through 64

Marsh Creek at Picton Landfill

RESULTS (ppm)

<u>MOE LAB NO.</u>	<u>HARDNESS</u> <u>(eq. CaCO₃)</u>	<u>Allcalinity</u> <u>(as CaCO₃)</u>	<u>Fe</u>	<u>Cl</u>	<u>pH</u>	<u>Conductivity</u> <u>(Mmhos/cm)</u>	<u>BOD₅</u>	<u>TOTAL</u> <u>SOLIDS</u>	<u>SO₄</u>
<u>June 1977</u>									
KW 27-1	232	250	0.20	44	7.7	690	<2	*	46
KW 27-2	212	188	0.35	85	8.0	700	<2	*	36
KW 27-3	240	210	0.55	77	8.0	720	<2	*	37
KW 27-4	240	218	1.8	77	7.9	725	<2	380	36
KW 27-5	268	248	1.8	21	7.8	550	<2	424	23
KW 27-6	276	254	2.3	53	7.4	680	<2	400	29
KW 27-7	292	264	3.0	55	7.5	720	<2	435	32
KW 27-8	292	270	1.9	56	7.6	715	<2	410	32

*sample exhausted

1977

SAMPLE LOCATIONS:MOE LAB NO.LOCATION

KW 27-1 through 8
 KW 32-59
 KW 32-60 through 64

Marsh Creek through Picton Landfill
 Storm sewer at Picton Landfill
 Marsh Creek at Picton Landfill

RESULTS (ppm)

<u>MOE LAB NO.</u>	<u>HARDNESS</u> <u>(eq. CaCO₃)</u>	<u>Alkalinity</u> <u>(asCaCO₃)</u>	<u>Fe</u>	<u>Cl</u>	<u>pH</u>	<u>Conductivity</u> <u>(Mmhos/cm)</u>	<u>BOD₅</u>	<u>TOTAL</u> <u>SOLIDS</u>	<u>SO₄</u>
August 1977									
KW 32-59	332	284	0.5	48	8.8	760	<4	*	47
KW 32-60	292	260	.25	74	8.0	800	<4	330	38
KW 32-61	292	262	.78	74	8.0	800	<4	340	37
KW 32-62	280	246	.30	23	8.0	560	<4	230	27
KW 32-63	292	270	1.1	45	7.9	690	<4	310	30
KW 32-64	304	280	1.8	42	7.8	720	<4	310	29

*sample exhausted

APPENDIX C:
RECORDS OF TEST HOLES

RECORD OF TEST HOLE			DESIGNATION	COMPLETION DATE				
PROJECT DELHI PARK LANDFILL, PICTON			P1	26/04/88				
PROJECT NO. P1690			DRILLING METHODS HOLLOW STEM AUGER					
			SUPERVISOR C. RYAN					
			DRILLING CONTRACTOR ALL TERRAIN DRILLING LTD.					
DEPTH		ELEVATION METERS	STRATIGRAPHY & HYDROSTRATIGRAPHY	LOG	INSTRUMENTATION	SAMPLING		
FT	M					TYPE	INTERVAL	N VALUE
0	0	80.90						
2			SILTY SAND - dark brown, few wood chips, rounded pebbles (0.5-1.0 cm0), occasional grey clay lenses					
4	1		SAND - grey, medium grained, clean, uniform			SS		
			SAND - grey, medium-coarse grained, grey clay lenses, cardboard pieces					
6	2	78.77	SAND - some fines			SS		
8			LANDFILL - dark grey, clean medium-to coarse grained sand with garbage (plastic, metal cardboard) - smells			SS		
10	3				1/2" PE tubing			
12								
14	4		- small sample volume, cardboard, plastic wrappers, dary grey cover sand			SS		
		76.33			Gas Probe			
16	5				seal			
18			- as above		1 1/4 " PVC	SS		
20	6	74.80			peastone gravel			
		74.50			10 slot screen, 1 1/2" PVC			
22	7	73.89	LANDFILL - 50% garbage with dark brown silty sand, occasional rounded pebbles (φ=1cm) smells			SS		
24			SAND - gray, medium grained, clean uniform, natural, few (<50%) rounded pebbles with φ<1cm - few fines give it low plasticity			SS		
26	8		SAND - as above, medium to coarse grained			SS		
28			SAND - as above		backfilled by sand caving	SS		
44								
46	14		SAND - as above		seal (46' to 48' deep	SS		
48								
73	22				backfilled by sand caving			
75		58.04	- coarse gravel, cobbles appear with and in auger cuttings		10 slot screen, 1 1/4" PVC			
76	23	57.74						

RECORD OF TEST HOLE			DESIGNATION	COMPLETION DATE			
PROJECT DELHI PARK LANDFILL, PICTON			P2	27/04/88			
PROJECT NO. P1690			DRILLING METHODS HOLLOW STEM AUGER				
			SUPERVISOR C. RYAN				
			DRILLING CONTRACTOR ALL TERRAIN DRILLING LTD.				
DEPTH FT M	ELEVATION METRES	STRATIGRAPHY & HYDROSTRATIGRAPHY	LOG	INSTRUMENTATION	SAMPLING		
					TYPE	INTERVAL	N VALUE
0	0	81.44					
4	1	SILTY SAND - dark brown, rounded pebbles 1-3 cmφ, cardboard and paper (<10%)					
8	2	SAND - grey-brown, medium to coarse grained, clean, (<10% garbage)			SS		3, 7, 10
12	3	CLEAN FILL - black/brown asphalt and sand, rounded pebbles			SS		1, 12
16	4	SAND - as far 5 1/2' to 6'					3, 4, 3, 4
20	5	LANDFILL - no sample in split spoon, garbage					
24	6	76.87					
28	7	LANDFILL - plastic, styrofoam, wood chips, lens of silty sand with high plasticity			SS		7, 8, 7, 10
32	8	75.33 SAND - medium brown, medium grained, uniform, wet, low plasticity					
36	9						
40	10	SAND - auger cuttings have some plasticity (can be rolled into a ball) - estimated 20% silt			grab		
44	11						
48	12						
52	13						
56	14						
60	15						
64	16						
68	17						
72	18						
76	19						
80	20						
84	21						
88	22						
92	23						
96	24						
100	25						
104	26						
108	27						
112	28						
116	29						
120	30						
124	31						
128	32						
132	33						
136	34						
140	35						
144	36						
148	37						
152	38						
156	39						
160	40						
164	41						
168	42						
172	43						
176	44						
180	45						
184	46						
188	47						
192	48						
196	49						
200	50						
204	51						
208	52						
212	53						
216	54						
220	55						
224	56						
228	57						
232	58						
236	59						
240	60						
244	61						
248	62						
252	63						
256	64						
260	65						
264	66						
268	67						
272	68						
276	69						
280	70						
284	71						
288	72						
292	73						
296	74						
300	75						
304	76						
308	77						
312	78						
316	79						
320	80						
324	81						
328	82						
332	83						
336	84						
340	85						
344	86						
348	87						
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356	89						
360	90						
364	91						
368	92						
372	93						
376	94						
380	95						
384	96						
388	97						
392	98						
396	99						
400	100						
404	101						
408	102						
412	103						
416	104						
420	105						
424	106						
428	107						
432	108						
436	109						
440	110						
444	111						
448	112						
452	113						
456	114						
460	115						
464	116						
468	117						
472	118						
476	119						
480	120						
484	121						
488	122						
492	123						
496	124						
500	125						
504	126						
508	127						
512	128						
516	129						
520	130						
524	131						
528	132						
532	133						
536	134						
540	135						
544	136						
548	137						
552	138						
556	139						
560	140						
564	141						
568	142						
572	143						
576	144						
580	145						
584	146						
588	147						
592	148						
596	149						
600	150						
604	151						
608	152						
612	153						
616	154						
620	155						
624	156						
628	157						
632	158						
636	159						
640	160						
644	161						
648	162						
652	163						
656	164						
660	165						
664	166						
668	167						
672	168						
676	169						
680	170						
684	171						
688	172						
692	173						
696	174						
700	175						
704	176						
708	177						
712	178						
716	179						
720	180						
724	181						
728	182						
732	183						
736	184						
740	185						
744	186						
748	187						
752	188						
756	189						
760	190						
764	191						
768	192						
772	193						
776	194						
780	195						
784	196						
788	197						
792	198						
796	199						
800	200						
804	201						
808	202						
812	203						
816	204						
820	205						
824	206						
828	207						
832	208						

RECORD OF TEST HOLE			DESIGNATION	COMPLETION DATE			
PROJECT DELHI PARK LANDFILL, PICTON			P3	April 27/88			
PROJECT NO. P1690			DRILLING METHODS HOLLOW STEM AUGER SUPERVISOR C. RYAN DRILLING CONTRACTOR ALL TERRAIN DRILLING LTD.				
DEPTH FT M	ELEVATION METRES	STRATIGRAPHY & HYDROSTRATIGRAPHY	LOG	INSTRUMENTATION	SAMPLING		
					TYPE	INTERVAL	N VALUE
0	0	76.42					
2	1	75.51					
4							
6	2						
8							
10	3						
12							
14	4						
16	5						
18							
20	6						
22	7						
24							
26	8						
28							
30	9						
32	10						
34							
36	11						

		RECORD OF TEST HOLE		DESIGNATION M1		COMPLETION DATE 27/04/88		
PROJECT DELHI PARK LANDFILL, PICTON				DRILLING METHODS HOLLOW STEM AUGER				
PROJECT NO. P1690				SUPERVISOR C. RYAN				
				DRILLING CONTRACTOR ALL TERRAIN DRILLING LTD.				
DEPTH		ELEVATION METRES	STRATIGRAPHY & HYDROSTRATIGRAPHY	LOG	INSTRUMENTATION	SAMPLING		
FT	M					TYPE	INTERVAL	N VALUE
0	0	81.94	Silty Sand - dark brown, medium grained, 10% rounded pebbles (Ø = 1 cm)					
1								
2								
3	1	81.03	Silty Sand - grey, medium to coarse grained, uniform, some cardboard					
4			Landfill - grey, medium grained, clean sand with garbage (wood chips, cardboard, asphalt, tire, glass) and rounded pebbles		Bentonite Seal			
5								
6	2					SS		5 1 4 55
7								
8								
9								
10	3				Gas Probe			
11								
12			Landfill - no sample in split spoon except a few pieces of rubber					
13	4					SS		6 5 10 24
14								
15		77.37	Landfill - cardboard, plastic with silty sand (medium grained)		Backfill			
16		76.99 76.91	Sand - grey brown, fine-medium grained, wet, non-cohesive, natural			SS		
17			Sand - grey, medium grained, uniform, fairly clean, non-cohesive					
18		76.45				SS		7 5 5 7

RECORD OF TEST HOLE

DESIGNATION

P4/M2

COMPLETION DATE

April 27/88

PROJECT DELHI PARK LANDFILL, PICTON

PROJECT NO. P1690

DRILLING METHODS HOLLOW STEM AUGER

SUPERVISOR C. RYAN

DRILLING CONTRACTOR ALL TERRAIN DRILLING LTD.

DEPTH FT M	ELEVATION METRES	STRATIGRAPHY & HYDROSTRATIGRAPHY	LOG	INSTRUMENTATION	SAMPLING		
					TYPE	INTERVAL	N VALUE
0	0	76.74					
1		Silty Sand: medium brown, 10% rounded pebbles (Ø 1 cm), uniform, low cohesion					
2							
3	1	75.83 Silty Sand: light brown, fine grained, moderate to high plasticity, uniform					
4		75.52 Landfill: brown black silty, medium grained sand with garbage- small sample volume					
5		75.52					
6							
7	2	75.45					
8		74.30 Landfill: dark black-grey, coarse grained silty sand with garbage (fibrous, medium grained sand with white flecks).					
9							
10	3						
11							
12							
13	4						
14							
15							
16							
17							
18							

APPENDIX D:
INORGANIC WATER CHEMISTRY RESULTS
FIELD MONITORING RESULTS



DEPARTMENT OF CHEMISTRY

Queen's University
Kingston, Canada
K7L 3N6

May 19, 1988

Results of Analyses of Water Samples for WESA

Submitted 11 May 1988 - Project 1690 - Cathy Ryan

<u>Trenton</u>	IRON (ppm)	MANGANESE (ppm)	COD (ppm)	ALKALINITY (ppm)	PHENOLS (ppb)	CHLORIDE (ppm)	NITRATE(N) (ppm)	SULPHATE (ppm)
P1-1	52.5	0.64	82	1290	10.8	970	<10	<2
P2-1	11.6	1.79	65	1010	6.0	195	<1	27
P3-1	9.0	1.01	77	945	<1.0	47	<1	4
P3-2	1.8	0.72	56	740	1.4	55	<1	61
P4-1	30.2	1.62	74	895	4.0	57	<1	<2
P4-2	4.9	1.65	320	920	6.6	185	<1	42
<u>Picton</u>								
P1-1	<0.10	0.09	<3	318	<1.0	81	<1	29
P1-2	11.1	2.85	154	1038	143	131	<1	28
P2-1	0.60	0.09	<3	296	<1.0	718	<1	9
P2-2	61.0	0.54	220	-	-	29	5.0	309
P3-1	<0.10	0.08	<3	285	<1.0	140	<1	9
P3-2	<0.10	1.40	6	483	<1.0	125	<1	25
P3-3	<0.10	<0.05	25	10	<1.0	<1	<1	<2
P3-4	0.15	0.19	12	251	<1.0	138	<1	10
P-4	11.2	0.08	27	291	3.0	142	<1	<2
			BOD					
<u>Trenton</u>								
SW1	<0.10	<0.05	<5	100	4.4	13	<1	12
SW2	<0.10	<0.05	<5	105	4.2	24	<1	16
<u>Picton</u>								
SW1	<0.10	0.08	<5	209	<1.0	56	5.0	59
SW2	<0.10	0.23	<5	230	<1.0	57.3	<1	5
SM1	<0.10	0.05	<5	502	-	166	<1	<2

	AMMONIUM as N (ppm)	CALCIUM (ppm)	MAGNESIUM (ppm)	POTASSIUM (ppm)	SODIUM (ppm)
<u>Trenton</u>					
P1-1	47.	310	42	32	470
P2-1	23.	324	43	10.9	106
P3-1	36.	270	43	36	78
P3-2	35.	174	26	27	160
P4-1	19	236	24	30	63
P4-2	33	240	26	28	145
<u>Picton</u>					
P1-1	<0.10	94	23	6.3	56
P1-2	19.	282	37	30	90
P2-1	0.47	136	46	11.5	460
P2-2	<0.10	-	-	-	-
P3-1	0.12	89	35	3.8	45
P3-2	0.23	170	40	2.7	34
P3-3	<0.10	<1.0	<1.0	0.7	2.1
P3-4	<0.10	80	38	3.9	46 46
P-4	8.5	83	13	10.8	68
<u>Trenton</u>					
SW1	<0.10	46	3.6	1.2	5.4
SW2	<0.10	48	3.9	1.5	9.5
<u>Picton</u>					
SW1	3.3	74	7.9	7.1	39
SW2	<0.10	80	7.5	2.0	13
SM1	14	143	41.	2.8	37

John S. Rink



ACCUTEST LABORATORIES LTD.

146 Colonnade Rd., Suite 202, Nepean, Ontario K2E 7Y3 (613) 727-5692

LAB REPORT NO.: A8-0415

REPORT OF ANALYSES

Client: Water & Earth Science Assoc.

Date: June 14, 1988

Attn: Ms. Cathy Ryan

Project: P 1690

Parameter	Units	Sample	Sample	Sample	Sample	Sample
		SM 1				
Fe	mg/L					
Mn	mg/L					
Hardness	mg/L CaCO ₃					
Alkalinity	mg/L CaCO ₃					
pH						
Conductivity	umhos					
F	mg/L					
Na	mg/L					
N-NO ₃	mg/L					
N-NO ₂	mg/L					
N-NH ₃	mg/L					
SO ₄	mg/L					
CL	mg/L					
Phenols	mg/L	<0.002				
Turbidity	NTU					
Colour	Pt/Co Units					
Ca	mg/L					
Mg	mg/L					
Tannin & Lignin	mg/L					
Total Nitrogen	mg/L					

ANALYST:

REPORT OF ANALYSES

Client: Water & Earth Science Assoc.

Date: October 7, 1988

Attn; Ms. Cathy Ryan

Project: 1690 PICTON

[illegible]

APPENDIX E:
ORGANIC CHEMISTRY RESULTS
(EPA 624 & 625 SCANS)



9420 CÔTE DE LIESSE, LACHINE, QUÉ. H8T 1A1

TÉL.: (514) 636-6218, 631-1838
TÉLEX: 05-822787 • (LYNJON)
FAX: (514) 631-9814

TO: Water & Earth Science Assoc.
Box 430
Carp, Ontario
K0A 1L0

DATE: June 13, 1988

CLIENT
ORDER #:

Attention: Ms. Cathy Ryan

REPORT #: NL-3680

RE: Analysis of Water Sample for VOC

Ms. Ryan,

Three (3) water samples were received June 7, 1988. One (1) of these samples and one (1) trip blank were analysed for volatile priority pollutants by purge and trap gc/ms. Results and detection limits are shown in the attached Table.

Chromatograms will be kept on file.

Sincerely,

NOVALAB LIMITED

B.E. Crowley, B.Sc.

Approved by J.D. Fenwick, Ph.D., P.Chem.

BEC/hl
encl.



CONCENTRATION OF ACIDIC PRIORITY POLLUTANTS IN WATER
ug/L

COMPOUND	T1690 P1-1	T1690 P2-1	T1690 P2-2	T1690 P1-2	T1690 P3-2	Trip blank	Lab blank	MDL
PHENOL	1.6	-	-	73	-	-	-	1
2-CHLOROPHENOL	-	-	-	-	-	-	-	1
2,4-DIMETHYLPHENOL	-	-	-	-	-	-	-	6
4-CHLORO-3-METHYLPHENOL	-	-	-	-	-	-	-	1
2,4-DICHLOROPHENOL	-	-	-	-	-	-	-	1
2,4,6-TRICHLOROPHENOL	-	-	-	-	-	-	-	1
2-NITROPHENOL	-	-	-	-	-	-	-	2
2,4-DINITROPHENOL	-	-	-	-	-	-	-	6
2-METHYL-4,6-DINITROPHENOL	-	-	-	-	-	-	-	5
4-NITROPHENOL	-	-	-	-	-	-	-	5
PENTACHLOROPHENOL	-	-	-	-	-	-	-	3

MDL = METHOD DETECTION LIMIT
TR = TRACE

RECOVERY OF SURROGATE STANDARDS

COMPOUND	T1690 P1-1	T1690 P2-1	T1690 P2-2	T1690 P1-2	T1690 P3-2	Trip blank	Lab blank
D5-PHENOL	58.6	40.6	54.7	56.8	-	58.5	64.5
TRIFLUOROMETHYL-M-CRESOL	81.6	69.5	82.9	67.4	-	79.2	81
D5-NITROBENZENE	65.4	72.3	80.1	74.5	82.7	80.1	77.7
D10-ANTHRACENE	76	81.1	88.7	79	75.7	77.8	78.6
D12-PERYLENE	67.5	67.6	75.3	71.4	71.4	74.2	77.8

CONCENTRATION OF BASE/NEUTRAL PRIORITY POLLUTANTS IN WATER
ug/L

COMPOUND	T1690 P1-1	T1690 P2-1	T1690 P2-2	T1690 P1-2	T1690 P3-2	Trip blank	Lab blank	MDL
ACENAPHTHENE	-	-	-	-	-	-	-	1
ACENAPHTHYLENE	-	-	-	-	-	-	-	1
ANTHRACENE	-	-	-	-	-	-	-	1
BENZIDINE	-	-	-	-	-	-	-	20
BENZ(A)ANTHRACENE	-	-	-	-	-	-	-	1
BENZO(B)FLUORANTHENE	-	-	-	-	-	-	-	2
BENZO(K)FLUORANTHENE	-	-	-	-	-	-	-	2
BENZO(A)PYRENE	-	-	-	-	-	-	-	3
BENZO(GHI)PERYLENE	-	-	-	-	-	-	-	5
BENZYL BUTYL PHTHALATE	-	-	-	-	-	-	-	1
BIS(2-CHLOROETHYL)ETHER	-	-	-	-	-	-	-	1
BIS(2-CHLOROETHOXY)METHANE	-	-	-	-	-	-	-	1
BIS(2-ETHYLHEXYL)PHTHALATE	1.5	1.2	1.2	1.2	-	2.6	2.3	1
BIS(2-CHLOROISOPROPYL)ETHER	-	-	-	-	-	-	-	1
4-BROMOPHENYL PHENYL ETHER	-	-	-	-	-	-	-	1
2-CHLORONAPHTHALENE	-	-	-	-	-	-	-	1
4-CHLOROPHENYL PHENYL ETHER	-	-	-	-	-	-	-	1
CHRYSENE	-	-	-	-	-	-	-	2
DIBENZ(A,H)ANTHRACENE	-	-	-	-	-	-	-	5
DI-N-BUTYL PHTHALATE	6.7	3.5	3	3.9	4.5	3	2.5	1
1,3-DICHLOROBENZENE	-	-	-	-	-	-	-	1
1,4-DICHLOROBENZENE	3.7	-	1.4	1.2	-	-	-	1
1,2-DICHLOROBENZENE	-	-	-	-	-	-	-	1
3,3'-DICHLOROBENZIDINE	-	-	-	-	-	-	-	1
DIETHYL PHTHALATE	2.7	-	-	2	-	-	-	1
DIMETHYL PHTHALATE	-	-	-	-	-	-	-	1
2,4-DINITROTOLUENE	-	-	-	-	-	-	-	3
2,6-DINITROTOLUENE	-	-	-	-	-	-	-	3
1,2-DIPHENYLHYDRAZINE	-	-	-	-	-	-	-	1
DI-N-OCTYL PHTHALATE	-	-	-	-	-	-	-	1
FLUORANTHENE	-	-	-	-	-	-	-	1
FLUORENE	-	-	1.4	-	-	-	-	1
HEXACHLOROBENZENE	-	-	-	-	-	-	-	1
HEXACHLOROBUTADIENE	-	-	-	-	-	-	-	3
HEXACHLOROCYCLOPENTADIENE	-	-	-	-	-	-	-	5
HEXACHLOROETHANE	-	-	-	-	-	-	-	3
INDENO(1,2,3-CD)PYRENE	-	-	-	-	-	-	-	5
ISOPHORONE	-	-	-	-	-	-	-	1
NAPHTHALENE	24	1.6	-	3	-	-	-	1
NITROBENZENE	-	-	-	-	-	-	-	1
N-NITROSO-DI-N-PROPYLAMINE	-	-	-	-	-	-	-	1
N-NITROSDIPHENYLAMINE	-	-	-	-	-	-	-	1
PHENANTHRENE	-	-	-	-	-	-	-	1
PYRENE	-	-	-	-	-	-	-	1
1,2,4-TRICHLOROBENZENE	-	-	-	-	-	-	-	1

MDL = METHOD DETECTION LIMIT

Total concentration of benzo(b)- and benzo(k)fluoranthene is shown in the row for benzo(k)fluoranthene.

CONCENTRATION OF VOLATILE PRIORITY POLLUTANTS IN WATER
ug/L

COMPOUND	T1690 -P2-1	TRIP BLANK	LAB BLANK	MDL
BENZENE	2.4	-	-	1
BROMODICHLOROMETHANE	-	-	-	1
BROMOFORM	-	-	-	2
BROMOMETHANE	-	-	-	10
CARBON TETRACHLORIDE	-	-	-	2
CHLOROBENZENE	1.1	-	-	1
CHLOROETHANE	-	-	-	10
2-CHLOROETHYL VINYL ETHER	-	-	-	10
CHLOROFORM	-	1.7	-	1
CHLOROMETHANE	-	-	-	50
DIBROMOCHLOROMETHANE	-	-	-	1
1,2-DICHLOROBENZENE	-	-	-	1
1,3-DICHLOROBENZENE	-	-	-	1
1,4-DICHLOROBENZENE	-	-	-	1
1,1-DICHLOROETHYLENE	-	-	-	1
1,1-DICHLOROETHANE	-	-	-	1
1,2-DICHLOROETHANE	-	-	-	2
TRANS-1,2-DICHLOROETHYLENE	-	-	-	1
DICHLOROMETHANE	-	-	-	10
1,2-DICHLOROPROPANE	-	-	-	1
CIS-1,3-DICHLOROPROPENE	-	-	-	1
TRANS-1,3-DICHLOROPROPENE	-	-	-	1
ETHYLBENZENE	1.7	-	-	1
A-METHYLSTYRENE	-	-	-	1
METHYLSTYRENE ISOMERS	1.9	-	-	1
MESITYLENE	-	-	-	1
1,1,2,2-TETRACHLOROETHANE	-	-	-	2
TETRACHLOROETHYLENE	-	-	-	1
TOLUENE	9.3	-	-	2
1,1,1-TRICHLOROETHANE	-	-	-	2
1,1,2-TRICHLOROETHANE	-	-	-	1
TRICHLOROETHYLENE	-	-	-	1
TRICHLOROFUOROMETHANE	-	-	-	2
M+P-XYLENE	6.7	-	-	2
O-XYLENE	3.5	-	-	1
VINYL CHLORIDE	-	-	-	12
OTHER AROMATIC COMPOUNDS	7.7	-	-	1

MDL = METHOD DETECTION LIMITS

OTHER AROMATIC COMPOUNDS = Total concentration of tri- and tetramethylbenzenes
using the response factor of mesitylene.

CONCENTRATION OF VOLATILE PRIORITY POLLUTANTS IN WATER
ug/L

COMPOUND	T1690 P1-1	T1690 P2-1	T1690 P2-2	P1640 P1-2	P1690 P2-3	BLANK	MDL
BENZENE	5.5	2.8	2.4	4.5	-	-	1
BROMODICHLOROMETHANE	-	-	-	-	-	-	1
BROMOFORM	-	-	-	-	-	-	2
BROMOMETHANE	-	-	-	-	-	-	18
CARBON TETRACHLORIDE	-	-	-	-	-	-	2
CHLOROBENZENE	32	2.4	4.2	3	-	-	1
CHLOROETHANE	-	-	-	-	-	-	10
2-CHLOROETHYL VINYL ETHER	-	-	-	-	-	-	10
CHLOROFORM	-	-	-	9.7	-	-	1
CHLOROMETHANE	-	-	-	-	-	-	50
DIBROMOCHLOROMETHANE	-	-	-	-	-	-	1
1,2-DICHLOROBENZENE	-	-	-	-	-	-	1
1,3-DICHLOROBENZENE	7.8	1.6	2.2	-	-	-	1
1,4-DICHLOROBENZENE	-	-	-	-	-	-	1
1,1-DICHLOROETHYLENE	-	-	-	2.8	-	-	1
1,1-DICHLOROETHANE	-	-	-	7.9	-	-	1
1,2-DICHLOROETHANE	-	-	-	-	-	-	2
TRANS-1,2-DICHLOROETHYLENE	-	-	-	-	-	-	1
DICHLOROMETHANE	-	-	-	-	-	-	10
1,2-DICHLOROPROPANE	-	-	-	-	-	-	1
CIS-1,3-DICHLOROPROPENE	-	-	-	-	-	-	1
TRANS-1,3-DICHLOROPROPENE	-	-	-	-	-	-	1
ETHYLBENZENE	1.6	1.4	3	12	-	-	1
A-METHYLSTYRENE	-	-	-	-	-	-	1
METHYLSTYRENE ISOMERS	-	-	-	-	-	-	1
MESITYLENE	-	-	-	-	-	-	1
1,1,2,2-TETRACHLOROETHANE	-	-	-	-	-	-	2
TETRACHLOROETHYLENE	-	-	-	1	-	-	1
TOLUENE	2.5	8	10	5.2	-	-	2
1,1,1-TRICHLOROETHANE	-	-	-	-	-	-	2
1,1,2-TRICHLOROETHANE	-	-	-	-	-	-	1
TRICHLOROETHYLENE	-	-	-	-	-	-	1
TRICHLOROFLUOROMETHANE	-	-	-	54	-	-	2
M+P-XYLENE	6.8	5.4	8.4	77	-	-	2
O-XYLENE	2	2.4	7.8	7.8	-	-	1
VINYL CHLORIDE	-	-	-	-	-	-	12
OTHER AROMATIC COMPOUNDS	170	11	15	140	-	-	1

MDL = METHOD DETECTION LIMITS

OTHER AROMATIC COMPOUNDS = Total concentration of tri- and tetramethylbenzenes
using the response factor of mesitylene.

CONCENTRATION OF VOLATILE PRIORITY POLLUTANTS IN WATER

ug/L

COMPOUND	SQU PICTON	SVI- PICTON	BLANK	MDL
BENZENE	-	-	-	1
BROMODICHLOROMETHANE	-	-	-	1
BROMOFORM	-	-	-	2
BROMOMETHANE	-	-	-	16
CARBON TETRACHLORIDE	-	-	-	2
CHLOROBENZENE	-	-	-	1
CHLOROETHANE	-	-	-	10
2-CHLOROETHYL VINYL ETHER	-	-	-	10
CHLOROFORM	-	3.5	-	1
CHLOROMETHANE	-	-	-	50
DIBROMOCHLOROMETHANE	-	-	-	1
1,2-DICHLOROBENZENE	-	1.3	-	1
1,3-DICHLOROBENZENE	-	-	-	1
1,4-DICHLOROBENZENE	-	-	-	1
1,1-DICHLOROETHYLENE	-	-	-	1
1,1-DICHLOROETHANE	-	-	-	1
1,2-DICHLOROETHANE	-	-	-	2
TRANS-1,2-DICHLOROETHYLENE	-	-	-	1
DICHLOROMETHANE	-	12	-	10
1,2-DICHLOROPROPANE	-	-	-	1
CIS-1,3-DICHLOROPROPENE	-	-	-	1
TRANS-1,3-DICHLOROPROPENE	-	-	-	1
ETHYLBENZENE	-	-	-	1
A-METHYLSTYRENE	-	-	-	1
METHYLSTYRENE ISOMERS	-	-	-	1
MESITYLENE	-	-	-	1
1,1,2,2-TETRACHLOROETHANE	-	-	-	2
TETRACHLOROETHYLENE	3.4	7.6	-	1
TOLUENE	-	-	-	2
1,1,1-TRICHLOROETHANE	-	TR	-	3
1,1,2-TRICHLOROETHANE	-	-	-	1
TRICHLOROETHYLENE	-	-	-	1
TRICHLOROFLOROMETHANE	-	-	-	2
M-P-XYLENE	-	-	-	2
O-XYLENE	-	-	-	1
VINYL CHLORIDE	-	-	-	12
OTHER AROMATIC COMPOUNDS	-	-	-	1

MDL = METHOD DETECTION LIMITS

TR = TRACE

OTHER AROMATIC COMPOUNDS = Total concentration of trimethylbenzenes
using the response factor of mesitylene.

APPENDIX F:
DUPLICATE AND BLANK SAMPLES

INORGANIC ANALYSES

DUPLICATE SAMPLE
FROM PICTON SITE
P3-1

FIELD
BLANK

PARAMETER

Fe (ppm)	<0.10	0.15	<0.10
Mn (ppm)	0.08	0.19	<0.05
COD (ppm)	<3	12	25
Alkalinity (ppm)	285	251	10
Phenols (ppb)	<1.0	<1.0	<1.0
Chloride (ppm)	140	138	<1
Nitrate-N (ppm)	<1	<1	<1
Sulphate (ppm)	9	10	<2
Ammonia-N (ppm)	0.12	<0.10	<0.10
Calcium (ppm)	89	80	<1.0
Magnesium (ppm)	35	38	<1.0
Potassium (ppm)	3.8	3.9	0.7
Sodium (ppm)	45	46	2.1
Calculated Hardness(ppm)	366	356	nil

ORGANIC ANALYSES

	DUPLICATE SAMPLES FROM TRENTON SITE P3-1			Trip Blank	Lab Blank
	1	2	3		
	May '88	May '88	June '88	June '88	
Benzene	3.4	2.7	2.4	-	-
Chlorobenzene	4.3	2.4	1.1	-	-
Chloroform	-	-	-	1.7	-
1,3-Dichlorobenzene	2.2	1.6	-	-	-
1,1-Dichloroethylene	-	-	-	-	-
1,1-Dichloroethane	-	-	-	-	-
Ethylbenzene	2	1.4	1.7	-	-
Methylstyrene Isomers	-	-	1.9	-	-
Tetrachlorethylene	-	-	-	-	-
Toluene	10	8	9.3	-	-
Trichlorofluoromethane	-	-	-	-	-
M+P-Xylene	8.4	5.4	6.7	-	-
O-Xylene	3.6	2.4	3.5	-	-
Other Aromatic Compounds	15	11	7.7	-	-

BASE/NEUTRAL PRIORITY POLLUTANTS (ug/l)

BIS(2-Ethylexyl)Phthalate	1.2	1.2	n/a	2.6	2.3
DI-N-Buthyl Phthalate	3.5	3	n/a	3	2.5
1,4-Dichlorobenzene	-	1.4	n/a	-	-
Diethyl Phthalate	-	-	n/a	-	-
Fluorene	-	1.4	n/a	-	-
Napthalene	1.6	-	n/a	-	-

ACIDIC PRIORITY POLLUTANTS (ug/l)

Phenol	-	-	n/a	-	-
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NOTE: Only those compounds with detectable concentrations are include in the table. A complete listing of the EPA 625 and 624 compounds analyzed are included in Appendix E.

* Drinking Water Objective (WESA, 1988)

** Method Detection Limit

TD
795.7
.H84
1989

Hydrogeological assessment of
Delhi park waste disposal site,
Pictou /
76875